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TESTA, HURWITZ & THIBEAULT, LLP
HIGH STREET TOWER
125 HIGH STREET
BOSTON, MA 02110

EXAMINER	
THANGAVELU, KANDASAMY	
ART UNIT	**PAPER NUMBER**
2123	13

DATE MAILED: 03/24/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/404,932	FRIEDL ET AL.	
	Examin r	Art Unit	
	Kandasamy Thangavelu	2123	

-- The MAILING DATE of this communication appears on the cover sheet with the corresp ndence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE <u>3</u> MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *29 December 2003*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-67* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-49,53-59 and 61-67* is/are rejected.

7)☒ Claim(s) *50-52 and 60* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *29 December 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

DETAILED ACTION

1. This communication is in response to the Applicants' Amendment dated December 29, 2003. Claims 1-7, 9, 10, 13, 14, 16-18, 21 and 22 were amended. Claims 26-67 were added. Claims 1-67 of the application are pending in the application. This office action is made final.

Response to Amendments

2. Applicant's arguments filed on December 29, 2003 have been fully considered. See response to Applicant's arguments, filed on December 29, 2003 regarding art rejections under 35 U.S.C. 103 (a) at Paragraph 20 below.

Drawings

3. The drawings submitted on December 29, 2003 are accepted.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to

> be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.

5. The factual inquiries set forth in Graham v. John Deere Co., 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

6. Claims 1-21, 26, 27, 30, 31, 34-36, 39, 40, 43-46 and 67 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Kataoka et al. (KA)** (U.S. Patent 6,077,472) and **Anderson et al. (AN)** (U.S. Patent 4,676,664).

6.1 **Yu** teaches Method for modeling three dimension objects and simulation of fluid flow. Specifically, as per Claim 1, **YU** teaches a method for modeling injection of a fluid into a mold defining a three dimensional cavity (Abs, L1-3; Fig. 15; CL1, L5-10; CL2, L39-42); the method comprising the steps of:

(a) providing a three-dimensional computer model defining the cavity (CL1, L11-13; CL1, L58-61; CL2, L39-45);

(b) discretizing a solution domain based on the model (CL2, L14-20; CL2, L22-24);

(d) solving for filling phase process variables over at least part of the solution domain to provide respective filling phase solutions therefor (CL1, L13-18; CL13, L12-27; CL1, L53-57); and

(e) solving for packing phase process variables over at least part of the solution domain using respective states of the process variables at termination of filling, to provide respective packing phase solutions therefor (CL1, L13-18; CL13, L12-27; CL1, L53-57).

YU does not expressly teach (c) specifying boundary conditions. **KE** teaches specifying boundary conditions (Pg 110, Para 7; Pg 150, Eq 9.4-9.9; Pg 186, Eq 10.5-10.9), as boundary conditions are physical effects that cause the system to change; boundary conditions restrict the number of possible solutions and ensure a unique solution to the problem under consideration (Pg. 110, Para 7). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included specifying boundary conditions, as boundary conditions are physical effects that cause the system to change; boundary conditions would restrict the number of possible solutions and ensure a unique solution to the problem under consideration.

YU does not expressly teach that at least one of steps (d) and (e) comprises the substep of using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain. **KA** teaches that at least one of steps (d) and (e) comprises the substep of using a first description of a distribution of a

process variable about each of a plurality of nodes or elements within the solution domain (Fig. 1-3; CL6, L46-67), as the temperature at different points within the injected semisolid can be determined as a function of the thermal diffusivity, the thickness of the part and time (CL6, L46-67). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KA** that included at least one of steps (d) and (e) comprising the substep of using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain, as the temperature at different points within the injected semisolid could be determined as a function of the thermal diffusivity, the thickness of the part and time.

AN teaches that at least one of steps (d) and (e) comprises the substep of using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **AN** that included at least one of steps (d) and (e) comprising the substep of using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain, as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow.

YU does not expressly teach that at least one of steps (d) and (e) comprises the substep of using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations. **KE** teaches that at least one of steps (d) and (e) comprises the substep of using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations (Pg 111, Para 6; Page 59, Para 1; Pg 107, Sec 6.7; Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to pg 188, Para 2), as conservation of mass means that the mass contained in a volume does not change (Pg 44, Sec 4.2); conservation of momentum requires that the time rate of change of the fluid momentum in a volume is equal to the sum of external forces acting on the volume (Pg 46, Sec 4.3); conservation of energy means that the total energy of fluid in a volume is given by the sum of kinetic and internal energies (Pg 47, Sec 4.4). As per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included at least one of steps (d) and (e) comprising the substep of using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising

conservation of mass, conservation of momentum, and conservation of energy equations, as conservation of mass would mean that the mass contained in a volume would not change; conservation of momentum would require that the time rate of change of the fluid momentum in a volume would be equal to the sum of external forces acting on the volume; conservation of energy would mean that the total energy of fluid in a volume would be given by the sum of kinetic and internal energies. On the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claim 2: **YU, KE, KA** and **AN** teach the method of Claim 1. **YU** teaches that the filling phase process variables and packing phase process variables are selected from the group consisting of density, fluidity, mold cavity fill time, mold cavity packing time, pressure, deformation rate, shear stress, temperature, internal energy, velocity, velocity gradient, flow rate,_viscosity, and volumetric shrinkage (CL13, L14-27).

Per Claim 3: **YU, KE, KA** and **AN** teach the method of Claim 1. **YU** teaches f) determining whether at least one of the respective filling phase solutions and packing phase solutions are acceptable (CL13, L27-33);

(g) modifying at least one of the discretized solution domain and the boundary conditions in the event at least one of the respective filling phase solutions and packing phase solutions is determined to be unacceptable (CL13, L27-41); and

(h) repeating steps (d) through (g), iteratively, until the respective filling phase solutions or packing phase solutions are determined to be acceptable (CL13, L27-38).

Per Claim 4: **YU, KE, KA** and **AN** teach the method of Claim 1. **YU** teaches computing a filling phase solution consisting of fill time, pressure, deformation rate, shear stress, temperature, velocity, and viscosity (CL13, L14-27). **YU** does not expressly teach displaying in graphics format a filling phase solution selected from the group consisting of fill time, pressure, deformation rate, shear stress, temperature, velocity, and viscosity. **KE** teaches displaying in graphics format a filling phase solution selected from the group consisting of fill time, pressure, deformation rate, shear stress, temperature, velocity, and viscosity (Pg 114, Para 1; Pg 149, Para 1 to Pg 152, Para 3), as analysis results in the tabular format are difficult to interpret and graphical displays can plot contours of the calculated variables over the model of the part for easy interpretation (Pg 114, Para 1). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included displaying in graphics format a filling phase solution selected from the group consisting of fill time, pressure, deformation rate, shear stress, temperature, velocity, and viscosity, as analysis results in the tabular format would be difficult to interpret and graphical displays could plot contours of the calculated variables over the model of the part for easy interpretation.

Per Claim 5: **YU, KE, KA** and **AN** teach the method of Claim 1. **YU** teaches computing a packing phase solution consisting of density, packing time, pressure, deformation rate, temperature, velocity, viscosity, and volumetric shrinkage (CL13, L14-27). **YU** does not expressly teach displaying in graphics format a packing phase solution selected from the group consisting of density, packing time, pressure, deformation rate, temperature, velocity, viscosity, and volumetric shrinkage. **KE** teaches displaying in

graphics format a packing phase solution selected from the group consisting of density, packing time, pressure, deformation rate, temperature, velocity, viscosity, and volumetric shrinkage (Pg 114, Para 1; Pg 185, Para 1 to Pg 188, Para 2), as analysis results in the tabular format are difficult to interpret and graphical displays can plot contours of the calculated variables over the model of the part for easy interpretation (Pg 114, Para 1). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included displaying in graphics format a filling phase solution selected from the group consisting of fill time, pressure, deformation rate, shear stress, temperature, velocity, and viscosity, as analysis results in the tabular format would be difficult to interpret and graphical displays could plot contours of the calculated variables over the model of the part for easy interpretation.

6.2 As per Claim 6, **YU** teaches a method for modeling injection of a fluid into a mold defining a three dimensional cavity (Abs, L1-3; Fig. 15; CL1, L5-10; CL2, L39-42); the method comprising the steps of:

(a) providing a three-dimensional computer model defining the cavity (CL1, L11-13; CL1, L58-61; CL2, L39-45);

(b) discretizing a solution domain based on the model (CL2, L14-20; CL2, L22-24); and

(d) solving for filling phase process variables over at least part of the solution domain to provide respective filling phase solutions therefor (CL1, L13-18; CL13, L12-27; CL1, L53-57).

YU does not expressly teach (c) specifying boundary conditions. **KE** teaches specifying boundary conditions (Pg 110, Para 7; Pg 150, Eq 9.4-9.9; Pg 186, Eq 10.5-10.9), as boundary conditions are physical effects that cause the system to change; boundary conditions restrict the number of possible solutions and ensure a unique solution to the problem under consideration (Pg. 110, Para 7). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included specifying boundary conditions, as boundary conditions are physical effects that cause the system to change; boundary conditions would restrict the number of possible solutions and ensure a unique solution to the problem under consideration.

YU does not expressly teach that the step (d) comprises the substep of using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain. **KA** teaches that the step (d) comprises the substep of using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain (Fig. 1-3; CL6, L46-67), as the temperature at different points within the injected semisolid can be determined as a function of the thermal diffusivity, the thickness of the part and time (CL6, L46-67). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KA** that included the step (d) comprising the substep of using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain, as the temperature at different points within the injected semisolid could be determined as a function of the thermal diffusivity, the thickness of the part and time.

AN teaches that the step (d) comprises the substep of using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **AN** that included the step (d) comprising the substep of using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain, as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow.

YU does not expressly teach that the step (d) comprises the substep of using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations. **KE** teaches that the step (d) comprises the substep of using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations (Pg 111, Para 6; Page 59, Para 1; Pg 107, Sec 6.7; Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to pg 188, Para 2), as conservation of mass means that the mass contained in

a volume does not change (Pg 44, Sec 4.2); conservation of momentum requires that the time rate of change of the fluid momentum in a volume is equal to the sum of external forces acting on the volume (Pg 46, Sec 4.3); conservation of energy means that the total energy of fluid in a volume is given by the sum of kinetic and internal energies (Pg 47, Sec 4.4). As per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the step (d) comprising the substep of using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations, as conservation of mass would mean that the mass contained in a volume would not change; conservation of momentum would require that the time rate of change of the fluid momentum in a volume would be equal to the sum of external forces acting on the volume; conservation of energy would mean that the total energy of fluid in a volume would be given by the sum of kinetic and internal energies. On the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claim 7: **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** teaches that the discretizing step (b) comprises the substep of generating a finite element mesh based on the solid model by subdividing the model into a plurality of connected elements defined by a plurality of nodes (CL2, L14-20; CL2, L22-24).

Per Claim 8: **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** does not expressly teach that the boundary conditions are selected from the group consisting of fluid composition, fluid injection location, fluid injection temperature, fluid injection pressure, fluid injection volumetric flow rate, mold temperature, cavity dimensions, cavity configuration, and mold parting plane, and variations thereof. **KE** teaches that the boundary conditions are selected from the group consisting of fluid composition, fluid injection location, fluid injection temperature, fluid injection pressure, fluid injection volumetric flow rate, mold temperature, cavity dimensions, cavity configuration, and mold parting plane, and variations thereof (Pg 5, Para 3; Pg 150, Eq 9.4-9.9; Pg 186, Eq 10.5-10.9), as boundary conditions are physical effects that cause the system to change; boundary conditions restrict the number of possible solutions and ensure a unique solution to the problem under consideration (Pg. 110, Para 7). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the boundary conditions selected from the group consisting of fluid composition, fluid injection location, fluid injection temperature, fluid injection pressure, fluid injection volumetric flow rate, mold temperature, cavity dimensions, cavity configuration, and mold parting plane, and

variations thereof, as boundary conditions are physical effects that cause the system to change; boundary conditions would restrict the number of possible solutions and ensure a unique solution to the problem under consideration.

Per Claim 9: **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** does not expressly teach that the solving step (d) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for fluidity over at least part of the solution domain;

(ii) solving for pressure over at least part of the solution domain; and

(iii) calculating velocity over at least part of the solution domain.

KE teaches that the solving step (d) utilizing the conservation of mass and conservation of momentum equations (Pg 149, Para 1 to Pg 152, Para 3) comprises the substeps of:

(i) solving for fluidity over at least part of the solution domain;

(ii) solving for pressure over at least part of the solution domain; and

(iii) calculating velocity over at least part of the solution domain (Pg 151, Para 1 to Pg 152, Para 3), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included that the solving step (d) utilizing

the conservation of mass and conservation of momentum equations comprising the substeps of:

(i) solving for fluidity over at least part of the solution domain;

(ii) solving for pressure over at least part of the solution domain; and

(iii) calculating velocity over at least part of the solution domain, because on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claims10-15: **YU, KE, KA** and **AN** teach the method of Claim 9. **YU** does not expressly teach the solving step (d) utilizing the conservation of energy equation comprises the substep of calculating viscosity over at least part of the solution domain; the viscosity calculating substep is based on temperature; at least one of velocity and viscosity is calculated iteratively, until pressure converges; the substep of determining free surface evolution of the fluid in the cavity based on velocity; the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution; and free surface evolution is determined iteratively, until the cavity is filled. **KE** teaches that the solving step (d) utilizing the conservation of energy equation comprises the substep of calculating viscosity over at least part of the solution domain; the viscosity calculating substep is based on temperature; at least one of velocity and viscosity is calculated iteratively, until pressure converges; the substep of determining free surface evolution of

the fluid in the cavity based on velocity; the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution; and free surface evolution is determined iteratively, until the cavity is filled (Pg 151, Para 1 to Pg 152, Para 3), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33).

It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the solving step (d) utilizing the conservation of energy equation comprising the substep of calculating viscosity over at least part of the solution domain; the viscosity calculating substep being based on temperature; at least one of velocity and viscosity being calculated iteratively, until pressure converges; the substep of determining free surface evolution of the fluid in the cavity based on velocity; the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution; and free surface evolution being determined iteratively, until the cavity is filled, because on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claim 16: **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** teaches packing phase and solving for packing phase process variables (CL1, L13-18; CL13, L12-27). **YU** does not expressly teach (e) solving for packing phase process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain based on respective states of the process variables at termination of filling, to provide respective packing phase solutions therefor for at least some of the portion of the solution domain. **KE** teaches (e) solving for packing phase process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain based on respective states of the process variables at termination of filling, to provide respective packing phase solutions therefor for at least some of the portion of the solution domain (Pg 107, Sec 6.7; Pg 113, Para 6; Pg 185, Para 1 to Pg 188, Para 2), as conservation of mass means that the mass contained in a volume does not change (Pg 44, Sec 4.2); conservation of momentum requires that the time rate of change of the fluid momentum in a volume is equal to the sum of external forces acting on the volume (Pg 46, Sec 4.3); conservation of energy means that the total energy of fluid in a volume is given by the sum of kinetic and internal energies (Pg 47, Sec 4.4); boundary conditions are physical effects that cause the system to change; boundary conditions restrict the number of possible solutions and ensure a unique solution to the problem under consideration (Pg. 110, Para 7). As per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been

obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included (e) solving for packing phase process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain based on respective states of the process variables at termination of filling, to provide respective packing phase solutions therefor for at least some of the portion of the solution domain, as conservation of mass would mean that the mass contained in a volume would not change; conservation of momentum would require that the time rate of change of the fluid momentum in a volume would be equal to the sum of external forces acting on the volume; conservation of energy would mean that the total energy of fluid in a volume would be given by the sum of kinetic and internal energies; boundary conditions are physical effects that would cause the system to change; boundary conditions would restrict the number of possible solutions and would ensure a unique solution to the problem under consideration. On the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claim 17: **YU, KE, KA** and **AN** teach the method of Claim 16. **YU** does not expressly teach that the solving step (e) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for fluidity over at least part of the solution domain;

(ii) solving for pressure over at least part of the solution domain; and

(iii) calculating velocity over at least part of the solution domain.

KE teaches that the solving step (e) utilizing the conservation of mass and conservation of momentum equations (Pg 185, Para 1 to Pg 186, Eq 4) comprises the substeps of:

(i) solving for fluidity over at least part of the solution domain;

(ii) solving for pressure over at least part of the solution domain; and

(iii) calculating velocity over at least part of the solution domain (Pg 185, Para 1 to Pg 188, Para 2), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included that the solving step (e) utilizing the conservation of mass and conservation of momentum equations comprising the substeps of:

(i) solving for fluidity over at least part of the solution domain;

(ii) solving for pressure over at least part of the solution domain; and

(iii) calculating velocity over at least part of the solution domain, because on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claims 18-21: **YU, KE, KA** and **AN** teach the method of Claim 16. **YU** does not expressly teach the solving step (e) utilizing the conservation of energy equation comprises the substep of calculating viscosity over at least part of the solution domain; the viscosity calculating substep is based on temperature; at least one of velocity and viscosity is calculated iteratively, until pressure converges; and the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution. **KE** teaches that the solving step (e) utilizing the conservation of energy equation comprises the substep of calculating viscosity over at least part of the solution domain; the viscosity calculating substep is based on temperature; at least one of velocity and viscosity is calculated iteratively, until pressure converges; and the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution (Pg 185, Para 1 to Pg 188, Para 2), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33).

It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the solving step (e) utilizing the conservation of energy equation comprising the substep of calculating viscosity over at least part of the solution domain; the viscosity calculating substep being based on temperature; at least one of velocity and viscosity being

calculated iteratively, until pressure converges; and the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution, because on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claims 26-27: **YU, KE, KA** and **AN** teach the method of Claim 1. **YU** does not expressly teach that at a given time step, the first description describes each of the plurality of nodes or elements independently of the others; and the value of the process variable at a first point provided by the first description of the process variable about a first node or element is not necessarily equal to the value of the process variable at the first point provided by the first description of the process variable about a second node or element. **KA** teaches that at a given time step, the first description describes each of the plurality of nodes or elements independently of the others; and the value of the process variable at a first point provided by the first description of the process variable about a first node or element is not necessarily equal to the value of the process variable at the first point provided by the first description of the process variable about a second node or element (Fig. 1-3; CL6, L46-67), as the temperature at different points within the injected semisolid can be determined as a function of the thermal diffusivity, the thickness of the part and time (CL6, L46-67). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KA** that included at a given time step, the first description describing each of the plurality

of nodes or elements independently of the others; and the value of the process variable at a first point provided by the first description of the process variable about a first node or element not being necessarily equal to the value of the process variable at the first point provided by the first description of the process variable about a second node or element, as the temperature at different points within the injected semisolid could be determined as a function of the thermal diffusivity, the thickness of the part and time.

AN teaches that at a given time step, the first description describes each of the plurality of nodes or elements independently of the others; and the value of the process variable at a first point provided by the first description of the process variable about a first node or element is not necessarily equal to the value of the process variable at the first point provided by the first description of the process variable about a second node or element (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **AN** that included at a given time step, the first description describing each of the plurality of nodes or elements independently of the others; and the value of the process variable at a first point provided by the first description of the process variable about a first node or element not being necessarily equal to the value of the process variable at the first point provided by the first description of the process variable about a second node or element, as the advective heat flow affects the temperature at different points in the semisolid and

the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow.

Per Claims 30-31: **YU, KE, KA** and **AN** teach the method of Claim 1. **YU** does not expressly teach that the first description describes a distribution of temperature or internal energy about a node or element; and the first description is or approximates a solution for one dimensional heat conduction in a solid. **KA** teaches that the first description describes a distribution of temperature or internal energy about a node or element; and the first description is or approximates a solution for one dimensional heat conduction in a solid (Fig. 1-3; CL6, L46-67), as the temperature at different points within the injected semisolid can be determined as a function of the thermal diffusivity, the thickness of the part and time using the equation for one dimensional heat conduction in a solid (CL6, L46-67). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KA** that included the first description describing a distribution of temperature or internal energy about a node or element; and the first description being or approximating a solution for one dimensional heat conduction in a solid, as the temperature at different points within the injected semisolid could be determined as a function of the thermal diffusivity, the thickness of the part and time using the equation for one dimensional heat conduction in a solid.

Per Claim 34: **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** teaches the step of determining whether the respective solutions are acceptable for injection of the fluid during filling of the mold cavity (CL13, L27-33).

Per Claims 35-36: **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** does not expressly teach that at a given time step, the first description describes each of the plurality of nodes or elements independently of the others; and the value of the process variable at a first point provided by a first description of the process variable about a first node or element differs from the value of the process variable at the first point provided by a first description of the process variable about a second node or element. **KA** teaches that at a given time step, the first description describes each of the plurality of nodes or elements independently of the others; and the value of the process variable at a first point provided by a first description of the process variable about a first node or element differs from the value of the process variable at the first point provided by a first description of the process variable about a second node or element (Fig. 1-3; CL6, L46-67), as the temperature at different points within the injected semisolid can be determined as a function of the thermal diffusivity, the thickness of the part and time (CL6, L46-67). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KA** that included at a given time step, the first description describing each of the plurality of nodes or elements independently of the others; and the value of the process variable at a first point provided by a first description of the process variable about a first node or element differing from the value of the process variable at the first point provided by a first description of the

process variable about a second node or element, as the temperature at different points within the injected semisolid could be determined as a function of the thermal diffusivity, the thickness of the part and time.

AN teaches that at a given time step, the first description describes each of the plurality of nodes or elements independently of the others; and the value of the process variable at a first point provided by a first description of the process variable about a first node or element differs from the value of the process variable at the first point provided by a first description of the process variable about a second node or element (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **AN** that included at a given time step, the first description describing each of the plurality of nodes or elements independently of the others; and the value of the process variable at a first point provided by a first description of the process variable about a first node or element differing from the value of the process variable at the first point provided by a first description of the process variable about a second node or element, as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow.

Per Claims 39-40: **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** does not expressly teach that the first description describes a distribution of temperature or internal energy about a node or element; and the first description is or approximates a solution for one dimensional heat conduction in a solid. **KA** teaches that the first description describes a distribution of temperature or internal energy about a node or element; and the first description is or approximates a solution for one dimensional heat conduction in a solid (Fig. 1-3; CL6, L46-67), as the temperature at different points within the injected semisolid can be determined as a function of the thermal diffusivity, the thickness of the part and time using the equation for one dimensional heat conduction in a solid (CL6, L46-67). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KA** that included the first description describing a distribution of temperature or internal energy about a node or element; and the first description being or approximating a solution for one dimensional heat conduction in a solid, as the temperature at different points within the injected semisolid could be determined as a function of the thermal diffusivity, the thickness of the part and time using the equation for one dimensional heat conduction in a solid.

Per Claim 43: **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** does not expressly teach that the solving step (d) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for pressure over at least part of the solution domain; and

(ii) calculating velocity over at least part of the solution domain.

KE teaches that the solving step (d) utilizing the conservation of mass and conservation of momentum equations (Pg 149, Para 1 to Pg 152, Para 3) comprises the substeps of:

(i) solving for pressure over at least part of the solution domain; and

(ii) calculating velocity over at least part of the solution domain (Pg 151, Para 1 to Pg 152, Para 3), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included that the solving step (d) utilizing the conservation of mass and conservation of momentum equations comprising the substeps of:

(i) solving for pressure over at least part of the solution domain; and

(ii) calculating velocity over at least part of the solution domain, because on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claim 44: **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** does not expressly teach that the solving step (d) comprises the substep of calculating temperature based on a convective heat transfer contribution, a conductive heat transfer contribution,

and a viscous dissipation contribution. **KE** teaches that the solving step (d) comprises the substep of calculating temperature based on a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution (Pg 151, Para 1 to Pg 152, Para 3), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the solving step (d) comprising the substep of calculating temperature based on a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution, because on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claim 45: **YU, KE, KA** and **AN** teach the method of Claim 16. **YU** does not expressly teach that the solving step (e) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for pressure over at least part of the solution domain; and

(ii) calculating velocity over at least part of the solution domain.

KE teaches that the solving step (e) utilizing the conservation of mass and conservation of momentum equations (Pg 185, Para 1 to Pg 186, Eq 4) comprises the substeps of:

(i) solving for pressure over at least part of the solution domain; and

(ii) calculating velocity over at least part of the solution domain (Pg 185, Para 1 to Pg 188, Para 2), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included that the solving step (e) utilizing the conservation of mass and conservation of momentum equations comprising the substeps of:

(i) solving for pressure over at least part of the solution domain; and

(ii) calculating velocity over at least part of the solution domain, because on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

Per Claim 46: **YU, KE, KA** and **AN** teach the method of Claim 16. **YU** does not expressly teach that the solving step (e) comprises the substep of calculating temperature based on a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution. **KE** teaches that the solving step (e) comprises the substep of calculating temperature based on a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution (Pg 185,

Para 1 to Pg 188, Para 2), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the solving step (e) comprising the substep of calculating temperature based on a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution, because on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part.

6.3 As per Claim 67, **YU** teaches an apparatus for modeling injection of a fluid into a mold defining a three dimensional cavity (Abs, L1-3; Fig. 15; CL1, L5-10; CL2, L39-42); the apparatus comprising:

a memory for storing code that defines a set of instructions and a processor for executing the set of instructions (CL1, L5-10; CL1, L58 to CL2, L2),

to discretize a solution domain based on a three dimensional computer model defining a cavity (CL2, L14-20; CL2, L22-24; CL1, L11-13; CL1, L58-61);

instructions to at least one of

(i) solving for filling phase process variables over at least part of the solution domain to provide respective filling phase solutions therefor (CL1, L13-18; CL13, L12-27; CL1, L53-57); and

(ii) solving for packing phase process variables over at least part of the solution domain using respective states of the process variables at termination of filling, to provide respective packing phase solutions therefor (CL1, L13-18; CL13, L12-27; CL1, L53-57).

YU does not expressly teach that at least one of steps (i) and (ii) comprises using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain. **KA** teaches that at least one of steps (i) and (ii) comprises using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain (Fig. 1-3; CL6, L46-67), as the temperature at different points within the injected semisolid can be determined as a function of the thermal diffusivity, the thickness of the part and time (CL6, L46-67). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the apparatus of **YU** with the apparatus of **KA** that included at least one of steps (i) and (ii) comprising using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain, as the temperature at different points within the injected semisolid could be determined as a function of the thermal diffusivity, the thickness of the part and time.

AN teaches that at least one of steps (i) and (ii) comprises using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow (CL13, L10-34). It would have been obvious to one

of ordinary skill in the art at the time of Applicants' invention to modify the apparatus of **YU** with the apparatus of **AN** that included at least one of steps (i) and (ii) comprising using a first description of a distribution of a process variable about each of a plurality of nodes or elements within the solution domain, as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow.

YU does not expressly teach that at least one of steps (i) and (ii) comprises using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations. **KE** teaches that at least one of steps (i) and (ii) comprises using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations (Pg 111, Para 6; Page 59, Para 1; Pg 107, Sec 6.7; Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to pg 188, Para 2), as conservation of mass means that the mass contained in a volume does not change (Pg 44, Sec 4.2); conservation of momentum requires that the time rate of change of the fluid momentum in a volume is equal to the sum of external forces acting on the volume (Pg 46, Sec 4.3); conservation of energy means that the total energy of fluid in a volume is given by the sum of kinetic and internal energies (Pg 47, Sec 4.4). As per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations,

processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the apparatus of **YU** with the apparatus of **KE** that included at least one of steps (i) and (ii) comprising using a second description of the distribution of the process variable in at least part of the solution domain comprising the plurality of nodes or elements, the second description comprising conservation of mass, conservation of momentum, and conservation of energy equations, as conservation of mass would mean that the mass contained in a volume would not change; conservation of momentum would require that the time rate of change of the fluid momentum in a volume would be equal to the sum of external forces acting on the volume; conservation of energy would mean that the total energy of fluid in a volume would be given by the sum of kinetic and internal energies. On the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

7. Claims 22-24 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Kataoka et al. (KA)** (U.S. Patent 6,077,472), **Anderson et al. (AN)** (U.S. Patent 4,676,664) and **Haverty (HA)** (U.S. Patent 5,989,473).

7.1 As per Claims 22 and 23, **YU, KE, KA** and **AN** teach the method of Claim 21. **YU** does not expressly teach (h) calculating mass properties of a component; and the mass properties are selected from the group consisting of component density, volumetric shrinkage, component mass, and component volume. **HA** teaches calculating mass properties of a component; and the mass properties are selected from the group consisting of component density, volumetric shrinkage, component mass, and component volume (CL 7, L13-43), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **HA** that included calculating mass properties of a component; and the mass properties would be selected from the group consisting of component density, volumetric shrinkage, component mass, and component volume, because on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part.

7.2 Per Claim 24: **YU, KE, KA, AN** and **HA** teach the method of Claim 22. **YU** does not expressly teach that at least one of velocity, viscosity, and mass properties is calculated iteratively, until a predetermined pressure profile is completed. **KE** teaches that at least one of velocity, viscosity, and mass properties is calculated iteratively, until a

predetermined pressure profile is completed (Pg 188, Para 2), because as per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included at least one of velocity, viscosity, and mass properties being calculated iteratively, until a predetermined pressure profile is completed, as on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part.

8. Claim 25 is rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Kataoka et al. (KA)** (U.S. Patent 6,077,472), **Anderson et al. (AN)** (U.S. Patent 4,676,664) and **Talwer et al. (TA)** ("Three dimensional simulation of polymer injection molding: verification", July 1998).

8.1 As per Claim 25, **YU, KE, KA** and **AN** teach the method of Claim 7. **YU** does not expressly teach that the mesh generating substep comprises generating an anisotropic mesh in thick and thin zones such that mesh refinement provides increased resolution in a thickness direction without increasing substantially mesh refinement in a longitudinal direction. **TA** teaches that the mesh generating substep comprises generating an

anisotropic mesh in thick and thin zones such that mesh refinement provides increased resolution in a thickness direction without increasing substantially mesh refinement in a longitudinal direction (Pg 53, CL1, Para 4 to CL2, Para 2), as the simulation process is made more effective in usage of resources by the employment of an anisotropic mesh that refines the mesh in the transverse direction to the flow (Pg 57, CL1, Para 2). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **TA** that included the mesh generating substep comprising generating an anisotropic mesh in thick and thin zones such that mesh refinement provides increased resolution in a thickness direction without increasing substantially mesh refinement in a longitudinal direction, as the simulation process would be made more effective in usage of resources by the employment of an anisotropic mesh that refines the mesh in the transverse direction to the flow.

9. Claims 28 and 37 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Kataoka et al. (KA)** (U.S. Patent 6,077,472), **Anderson et al. (AN)** (U.S. Patent 4,676,664) and **Chen et al. (CH)** (U.S. Patent 6,089,744).

9.1 As per Claim 28, **YU, KE, KA** and **AN** teach the method of Claim 1. **YU** does not expressly teach that the value of the process variable at a first point provided by the first description of the process variable about a node or element is used in the second description. **AN** teaches the value of the process variable at a first point provided by the

first description of the process variable about a node or element (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **AN** that included the value of the process variable at a first point provided by the first description of the process variable about a node or element, as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow.

YU does not expressly teach the value of the process variable at a first point provided by the first description of the process variable about a node or element is used in the second description. **CH** teaches that the value of the process variable at a first point provided by the first description of the process variable about a node or element is used in the second description (CL8, L26-64), as to correctly simulate the heat flow, during each time increment of simulation, the movement of particles is simulated by an advection stage that accounts for the interactions of the particles with the mold and then the simulation is corrected such that the process meets the conservation of mass, momentum and energy constraints a t the boundaries (CL8, L26-64). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **CH** that included the value of the process variable at a first point provided by the first description of the process variable about a node or element

being used in the second description, as to correctly simulate the heat flow, during each time increment of simulation, the movement of particles must be simulated by an advection stage that accounted for the interactions of the particles with the mold and then the simulation must be corrected such that the process met the conservation of mass, momentum and energy constraints at the boundaries.

9.2 As per Claim 37, **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** does not expressly teach that the value of the process variable at a first point provided by the first description of the process variable about a node or element is used in the second description. **AN** teaches the value of the process variable at a first point provided by the first description of the process variable about a node or element (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **AN** that included the value of the process variable at a first point provided by the first description of the process variable about a node or element, as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow.

YU does not expressly teach the value of the process variable at a first point provided by the first description of the process variable about a node or element is used in

the second description. **CH** teaches that the value of the process variable at a first point provided by the first description of the process variable about a node or element is used in the second description (CL8, L26-64), as to correctly simulate the heat flow, during each time increment of simulation, the movement of particles is simulated by an advection stage that accounts for the interactions of the particles with the mold and then the simulation is corrected such that the process meets the conservation of mass, momentum and energy constraints a t the boundaries (CL8, L26-64). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **CH** that included the value of the process variable at a first point provided by the first description of the process variable about a node or element being used in the second description, as to correctly simulate the heat flow, during each time increment of simulation, the movement of particles must be simulated by an advection stage that accounted for the interactions of the particles with the mold and then the simulation must be corrected such that the process met the conservation of mass, momentum and energy constraints at the boundaries.

10. Claims 29 and 38 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Kataoka et al. (KA)** (U.S. Patent 6,077,472), **Anderson et al. (AN)** (U.S. Patent 4,676,664) and **Sandstorm (SA)** (U.S. Patent 6,180,201).

10.1 As per Claim 29, **YU, KE, KA** and **AN** teach the method of Claim 1. **YU** does not expressly teach that the first description is a one dimensional analytic function or is a discrete function. **SA** teaches that the first description is a one dimensional analytic function or is a discrete function (CL12, L15-28), as one dimensional conduction dominates in the semisolid in the injection molding and can be determined using the distance in the thickness direction and the coefficient of thermal diffusivity (CL12, L16-24). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **SA** that included the first description being a one dimensional analytic function or a discrete function, as one dimensional conduction would dominate in the semisolid in the injection molding and could be determined using the distance in the thickness direction and the coefficient of thermal diffusivity.

10.2 As per Claim 38, **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** does not expressly teach that the first description is a one dimensional analytic function or is a discrete function. **SA** teaches that the first description is a one dimensional analytic function or is a discrete function (CL12, L15-28), as one dimensional conduction dominates in the semisolid in the injection molding and can be determined using the distance in the thickness direction and the coefficient of thermal diffusivity (CL12, L16-24). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **SA** that included the first description being a one dimensional analytic function or a discrete function, as one dimensional conduction would dominate in the semisolid in the injection molding

and could be determined using the distance in the thickness direction and the coefficient of thermal diffusivity.

11. Claims 32, 33, 41 and 42 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Kataoka et al. (KA)** (U.S. Patent 6,077,472), **Anderson et al. (AN)** (U.S. Patent 4,676,664) and **Tannenbaum et al. (TAN)** (U.S. Patent 6,248,103).

11.1 As per Claims 32-33, **YU, KE, KA** and **AN** teach the method of Claim 1. **YU** does not expressly teach that the first description comprises or is derived from an error function; and the first description is a one dimensional description of temperature distribution about a node or element, the description comprising an error function. **TAN** teaches that the first description comprises or is derived from an error function; and the first description is a one dimensional description of temperature distribution about a node or element, the description comprising an error function (CL6, L65 to CL7, L22), as the temperature at any point can be determined using the distance in one dimension, thermal conductivity, thermal diffusivity and the error function (CL7, L6-10). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **TAN** that included the first description comprising or being derived from an error function; and the first description being a one dimensional description of temperature distribution about a node or element, the description comprising an error function, as the temperature at any point could be determined using

the distance in one dimension, thermal conductivity, thermal diffusivity and the error function.

11.2 As per Claims 41-42, **YU, KE, KA** and **AN** teach the method of Claim 6. **YU** does not expressly teach that the first description comprises or is derived from an error function; and the first description is a one dimensional description of temperature distribution about a node or element, the description comprising an error function. **TAN** teaches that the first description comprises or is derived from an error function; and the first description is a one dimensional description of temperature distribution about a node or element, the description comprising an error function (CL6, L65 to CL7, L22), as the temperature at any point can be determined using the distance in one dimension, thermal conductivity, thermal diffusivity and the error function (CL7, L6-10). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **TAN** that included the first description comprising or being derived from an error function; and the first description being a one dimensional description of temperature distribution about a node or element, the description comprising an error function, as the temperature at any point could be determined using the distance in one dimension, thermal conductivity, thermal diffusivity and the error function.

12. Claims 47-49, 54, 65 and 66 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of

Anderson et al. (AN) (U.S. Patent 4,676,664) and **Chen et al. (CH)** (U.S. Patent 6,089,744).

12.1 As per Claim 47, **YU** teaches a method for modeling injection of a fluid into a mold defining a three dimensional cavity (Abs, L1-3; Fig. 15; CL1, L5-10; CL2, L39-42); the method comprising the steps of:

(a) providing a three-dimensional computer model defining the cavity (CL1, L11-13; CL1, L58-61; CL2, L39-45); and

(b) discretizing a solution domain based on the model (CL2, L14-20; CL2, L22-24);

YU does not expressly teach (c) specifying boundary conditions. **KE** teaches specifying boundary conditions (Pg 110, Para 7; Pg 150, Eq 9.4-9.9; Pg 186, Eq 10.5-10.9), as boundary conditions are physical effects that cause the system to change; boundary conditions restrict the number of possible solutions and ensure a unique solution to the problem under consideration (Pg. 110, Para 7). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included specifying boundary conditions, as boundary conditions are physical effects that cause the system to change; boundary conditions would restrict the number of possible solutions and ensure a unique solution to the problem under consideration.

YU does not expressly teach (d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain. **KE** teaches (d) solving for process variables using

conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain (Pg 111, Para 6; Page 59, Para 1; Pg 107, Sec 6.7; Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to pg 188, Para 2), as conservation of mass means that the mass contained in a volume does not change (Pg 44, Sec 4.2); conservation of momentum requires that the time rate of change of the fluid momentum in a volume is equal to the sum of external forces acting on the volume (Pg 46, Sec 4.3); conservation of energy means that the total energy of fluid in a volume is given by the sum of kinetic and internal energies (Pg 47, Sec 4.4). As per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included (d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain, as conservation of mass would mean that the mass contained in a volume would not change; conservation of momentum would require that the time rate of change of the fluid momentum in a volume would be equal to the sum of external forces acting on the volume; conservation of energy would mean that the total energy of fluid in a volume would be given by the sum of kinetic and internal energies. On the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

YU does not expressly teach that step (d) comprises the substep of using an explicit scheme in solving the conservation of energy equation. **AN** teaches the computation of temperature change due to advective heat flow at a point in the semisolid using an explicit scheme (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow using a one dimensional function (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **AN** that included the computation of temperature change due to advective heat flow at a point in the semisolid using an explicit scheme, as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow using a one dimensional function.

CH teaches that step (d) comprises the substep of using an explicit scheme in solving the conservation of energy equation (CL8, L26-64), as to correctly simulate the heat flow, during each time increment of simulation, the movement of particles is simulated by an advection stage that accounts for the interactions of the particles with the mold and then the simulation is corrected such that the process meets the conservation of mass, momentum and energy constraints a t the boundaries (CL8, L26-64). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **CH** that included the step (d) comprising the substep of using an explicit scheme in solving the conservation of energy equation, as

to correctly simulate the heat flow, during each time increment of simulation, the movement of particles must be simulated by an advection stage that accounted for the interactions of the particles with the mold and then the simulation must be corrected such that the process met the conservation of mass, momentum and energy constraints at the boundaries.

Per Claims 48-49: **YU, KE, KA** and **AN** teach the method of Claim 47. **YU** does not expressly teach that the explicit scheme is an explicit temperature convection scheme; and the explicit scheme comprises a one dimensional analytic function, data derived from a one dimensional analytic function, or a discrete function describing the temperature distribution about a node. **AN** teaches that the explicit scheme is an explicit temperature convection scheme; and the explicit scheme comprises a one dimensional analytic function, data derived from a one dimensional analytic function, or a discrete function describing the temperature distribution about a node (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow using a one dimensional function (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **AN** that included the explicit scheme being an explicit temperature convection scheme; and the explicit scheme comprising a one dimensional analytic function, data derived from a one dimensional analytic function, or a discrete function describing the temperature distribution about a node, as the advective heat flow would affect the temperature at

different points in the semisolid and the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow using a one dimensional function.

Per Claim 54: **YU, KE, KA** and **AN** teach the method of Claim 47. **YU** does not expressly teach that step (d) comprises the substep of calculating contribution to heat transfer due to at least one of viscous dissipation, heat of compression, heat of decompression, heat of solidification, and heat of reaction. **KE** teaches that step (d) comprises the substep of calculating contribution to heat transfer due to at least one of viscous dissipation, heat of compression, heat of decompression, heat of solidification, and heat of reaction (Pg 15, Para 2; Page 21, Para 2; Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to Pg 188, Para 2), as shear heating is caused by the deformation of the melt as it flows into the cavity (Pg15, Para 2), which is indicated by the viscosity of the material (Pg 21, Para 3). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included step (d) comprising the substep of calculating contribution to heat transfer due to at least one of viscous dissipation, heat of compression, heat of decompression, heat of solidification, and heat of reaction, as shear heating would be caused by the deformation of the melt as it flowed into the cavity, which would be indicated by the viscosity of the material.

12.2 As per Claim 65, **YU** teaches an apparatus for modeling injection of a fluid into a mold defining a three dimensional cavity (Abs, L1-3; Fig. 15; CL1, L5-10; CL2, L39-42); the apparatus comprising:

a memory for storing code that defines a set of instructions and a processor for executing the set of instructions (CL1, L5-10; CL1, L58 to CL2, L2),

to discretize a solution domain based on a three dimensional computer model defining a cavity (CL2, L14-20; CL2, L22-24; CL1, L11-13; CL1, L58-61);

YU does not expressly teach the set of instructions to solve for process variables using conservation of mass, conservation of momentum and conservation of energy equations. **KE** teaches the set of instructions to solve for process variables using conservation of mass, conservation of momentum and conservation of energy equations (Pg 111, Para 6; Page 59, Para 1; Pg 107, Sec 6.7; Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to pg 188, Para 2), as conservation of mass means that the mass contained in a volume does not change (Pg 44, Sec 4.2); conservation of momentum requires that the time rate of change of the fluid momentum in a volume is equal to the sum of external forces acting on the volume (Pg 46, Sec 4.3); conservation of energy means that the total energy of fluid in a volume is given by the sum of kinetic and internal energies (Pg 47, Sec 4.4). As per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the apparatus of **YU** with the apparatus of **KE** that included the set of instructions to solve for process variables using conservation of mass, conservation of momentum and conservation of energy equations, as conservation of mass would mean that the mass contained in a volume would not change; conservation of momentum would require that the time rate of change

of the fluid momentum in a volume would be equal to the sum of external forces acting on the volume; conservation of energy would mean that the total energy of fluid in a volume would be given by the sum of kinetic and internal energies. On the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

YU does not expressly teach that an explicit scheme is used to solve the conservation of energy equation. **AN** teaches the computation of temperature change due to advective heat flow at a point in the semisolid using an explicit scheme (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow using a one dimensional function (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the apparatus of **YU** with the apparatus of **AN** that included instruction for the computation of temperature change due to advective heat flow at a point in the semisolid using an explicit scheme, as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow using a one dimensional function.

CH teaches that an explicit scheme is used to solve the conservation of energy equation (CL8, L26-64), as to correctly simulate the heat flow, during each time increment of simulation, the movement of particles is simulated by an advection stage

that accounts for the interactions of the particles with the mold and then the simulation is corrected such that the process meets the conservation of mass, momentum and energy constraints a t the boundaries (CL8, L26-64). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **CH** that included an explicit scheme being used to solve the conservation of energy equation, as to correctly simulate the heat flow, during each time increment of simulation, the movement of particles must be simulated by an advection stage that accounted for the interactions of the particles with the mold and then the simulation must be corrected such that the process met the conservation of mass, momentum and energy constraints at the boundaries.

Per Claim 66: **YU, KE, KA** and **AN** teach the apparatus of Claim 65. **YU** does not expressly teach that the explicit scheme is an explicit temperature convection scheme. **AN** teaches that the explicit scheme is an explicit temperature convection scheme (CL13, L10-50), as the advective heat flow affects the temperature at different points in the semisolid and the temperature variation at different points can be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow using a one dimensional function (CL13, L10-34). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the apparatus of **YU** with the apparatus of **AN** that included the explicit scheme being an explicit temperature convection scheme, as the advective heat flow would affect the temperature at different points in the semisolid and the temperature variation at different

points could be found from the temperatures at the end points of advection and the Peclet number for the advective heat flow using a one dimensional function.

13. Claim 53 is rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al.** **(YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Anderson et al. (AN)** (U.S. Patent 4,676,664), **Chen et al. (CH)** (U.S. Patent 6,089,744), and **Sen et al. (SE)** (U.S. Patent 5,311,932).

13.1 As per Claim 53, **YU, KE, KA** and **AN** teach the method of Claim 47. **YU** does not expressly teach that step (d) comprises determining temperature at an upstream position corresponding to a particle location at a previous time step. **SE** teaches that step (d) comprises determining temperature at an upstream position corresponding to a particle location at a previous time step (CL7, L2-18), as the temperature does not change with the flow of the particle as indicated by the Peclet number (CL7, L2-18). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **SE** that included step (d) comprising determining temperature at an upstream position corresponding to a particle location at a previous time step, as the temperature would not change with the flow of the particle as indicated by the Peclet number.

14. Claim 55 is rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al.** **(YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection

Molds", Hanser Publishers, 1995), and further in view of **Talwer et al. (TA)** ("Three dimensional simulation of polymer injection molding: verification", July 1998).

14.1 As per Claim 55, **YU** teaches a method for modeling injection of a fluid into a mold defining a three dimensional cavity (Abs, L1-3; Fig. 15; CL1, L5-10; CL2, L39-42); the method comprising the steps of:

(a) providing a three-dimensional computer model defining the cavity (CL1, L11-13; CL1, L58-61; CL2, L39-45); and

(b) discretizing a solution domain based on the model (CL2, L14-20; CL2, L22-24); wherein

step (b) comprises the substep of generating a finite element mesh based on the model by subdividing the model into a plurality of connected elements defined by a plurality of nodes (CL1, L30-32; CL2, L14-20; Fig. 16; CL12, L36-48).

YU does not expressly teach (c) specifying boundary conditions. **KE** teaches specifying boundary conditions (Pg 110, Para 7; Pg 150, Eq 9.4-9.9; Pg 186, Eq 10.5-10.9), as boundary conditions are physical effects that cause the system to change; boundary conditions restrict the number of possible solutions and ensure a unique solution to the problem under consideration (Pg. 110, Para 7). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included specifying boundary conditions, as boundary conditions are physical effects that cause the system to change; boundary conditions would restrict the number of possible solutions and ensure a unique solution to the problem under consideration.

YU does not expressly teach (d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain. **KE** teaches (d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain (Pg 111, Para 6; Page 59, Para 1; Pg 107, Sec 6.7; Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to pg 188, Para 2), as conservation of mass means that the mass contained in a volume does not change (Pg 44, Sec 4.2); conservation of momentum requires that the time rate of change of the fluid momentum in a volume is equal to the sum of external forces acting on the volume (Pg 46, Sec 4.3); conservation of energy means that the total energy of fluid in a volume is given by the sum of kinetic and internal energies (Pg 47, Sec 4.4). As per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included (d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain, as conservation of mass would mean that the mass contained in a volume would not change; conservation of momentum would require that the time rate of change of the fluid momentum in a volume would be equal to the sum of external forces acting on the volume; conservation of energy would mean that the total energy of fluid in a volume would be given by the sum of kinetic and internal energies. On the basis of calculated

data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

YU does not expressly teach that step (b) comprises the substep of anisotropically refining the mesh such that there are more nodes in a first direction of greater variation of material properties than in a second direction of lesser variation of material properties, the refinement comprising at least one of the substeps of calculating a distance from a node to a boundary; and using a node layer numbering system. **TA** teaches that step (b) comprises the substep of anisotropically refining the mesh such that there are more nodes in a first direction of greater variation of material properties than in a second direction of lesser variation of material properties, the refinement comprising at least one of the substeps of calculating a distance from a node to a boundary; and using a node layer numbering system (Pg 53, CL1, Para 4 to CL2, Para 2), as the simulation process is made more effective in usage of resources by the employment of an anisotropic mesh that refines the mesh in the transverse direction to the flow (Pg 57, CL1, Para 2). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **TA** that included that step (b) comprising the substep of anisotropically refining the mesh such that there were more nodes in a first direction of greater variation of material properties than in a second direction of lesser variation of material properties, the refinement comprising at least one of the substeps of calculating a distance from a node to a boundary; and using a node layer numbering system, as the simulation process would be made more effective in

usage of resources by the employment of an anisotropic mesh that refines the mesh in the transverse direction to the flow.

15. Claims 56-59 and 61 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995).

15.1 As per Claim 56, **YU** teaches a method for modeling injection of a fluid into a mold defining a three dimensional cavity (Abs, L1-3; Fig. 15; CL1, L5-10; CL2, L39-42); the method comprising the steps of:

(a) providing a three-dimensional computer model defining the cavity (CL1, L11-13; CL1, L58-61; CL2, L39-45); and

(b) discretizing a solution domain based on the model (CL2, L14-20; CL2, L22-24); wherein

step (b) comprises the substep of generating a finite element mesh based on the model by subdividing the model into a plurality of connected elements defined by a plurality of nodes (CL1, L30-32; CL2, L14-20; Fig. 16; CL12, L36-48).

YU does not expressly teach (c) specifying boundary conditions. **KE** teaches specifying boundary conditions (Pg 110, Para 7; Pg 150, Eq 9.4-9.9; Pg 186, Eq 10.5-10.9), as boundary conditions are physical effects that cause the system to change; boundary conditions restrict the number of possible solutions and ensure a unique solution to the problem under consideration (Pg. 110, Para 7). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify

the method of **YU** with the method of **KE** that included specifying boundary conditions, as boundary conditions are physical effects that cause the system to change; boundary conditions would restrict the number of possible solutions and ensure a unique solution to the problem under consideration.

YU does not expressly teach (d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain. **KE** teaches (d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain (Pg 111, Para 6; Page 59, Para 1; Pg 107, Sec 6.7; Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to pg 188, Para 2), as conservation of mass means that the mass contained in a volume does not change (Pg 44, Sec 4.2); conservation of momentum requires that the time rate of change of the fluid momentum in a volume is equal to the sum of external forces acting on the volume (Pg 46, Sec 4.3); conservation of energy means that the total energy of fluid in a volume is given by the sum of kinetic and internal energies (Pg 47, Sec 4.4). As per **YU**, on the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding may be evaluated for their efficacy in improving the quality or manufacturability of part (CL13, L27-33). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included (d) solving for process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain, as conservation of mass would mean that the mass contained in a volume would not change;

conservation of momentum would require that the time rate of change of the fluid momentum in a volume would be equal to the sum of external forces acting on the volume; conservation of energy would mean that the total energy of fluid in a volume would be given by the sum of kinetic and internal energies. On the basis of calculated data and derived information, changes to the component geometry, position of the injection locations, processing conditions and material of the molding might be evaluated for their efficacy in improving the quality or manufacturability of part.

YU does not expressly teach that step (d) comprises the substep of determining a location of a solid/liquid interface, the determination of the interface comprising the substep of determining locations at which a process variable achieves a given value. **KE** teaches that step (d) comprises the substep of determining a location of a solid/liquid interface, the determination of the interface comprising the substep of determining locations at which a process variable achieves a given value (Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to pg 188, Para 2), as it enables determination of completion of the filling phase (Pg 152, Para 1) and packing phase (Pg 188, Para 2). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the step (d) comprising substep of determining a location of a solid/liquid interface, the determination of the interface comprising the substep of determining locations at which a process variable achieved a given value, as it would enable determination of completion of the filling phase and packing phase.

15.2 As per Claim 57, **YU** and **KE** teach the method of Claim 56. **YU** does not expressly teach that the process variable of step (d) which is used to determine a location of a solid/liquid interface is one of the group consisting of temperature, velocity, and a process variable combining temperature and velocity. **KE** teaches that the process variable of step (d) which is used to determine a location of a solid/liquid interface is one of the group consisting of temperature, velocity, and a process variable combining temperature and velocity (Pg 149, Para 1 to Pg 152, Para 3; Pg 185, Para 1 to Pg 188, Para 2), as it enables determination of completion of the filling phase (Pg 152, Para 1) and packing phase (Pg 188, Para 2). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the process variable of step (d) which would be used to determine a location of a solid/liquid interface would be one of the group consisting of temperature, velocity, and a process variable combining temperature and velocity, as it would enable determination of completion of the filling phase and packing phase.

15.3 As per Claim 58, **YU** and **KE** teach the method of Claim 56. **YU** does not expressly teach that step (d) further comprises the substep of determining an effective viscosity for each of a plurality of elements containing the solid/liquid interface by calculating a volume fraction of freeze within the element. **KE** teaches that step (d) further comprises the substep of determining an effective viscosity for each of a plurality of elements containing the solid/liquid interface by calculating a volume fraction of freeze within the element (Pg 185, Para 1 to Pg 188, Para 2), as it enables determination of completion of the packing phase (Pg 188, Para 2). It would have been obvious to one

of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the step (d) further comprising the substep of determining an effective viscosity for each of a plurality of elements containing the solid/liquid interface by calculating a volume fraction of freeze within the element, as it would enable determination of completion of packing phase.

15.4 As per Claims 59 and 61, **YU** and **KE** teach the method of Claim 56. **YU** does not expressly teach that step (d) further comprises the substep of determining an effective pressure at a position in the solution domain by identifying core nodes within the solution domain; and the substep of projecting a core pressure onto an outer cavity frozen layer. **KE** teaches that step (d) further comprises the substep of determining an effective pressure at a position in the solution domain by identifying core nodes within the solution domain; and the substep of projecting a core pressure onto an outer cavity frozen layer (Pg 185, Para 1 to Pg 188, Para 2), as it enables determination of density using PVT data and determination of completion of the packing phase (Pg 188, Para 2). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **KE** that included the step (d) further comprising the substep of determining an effective pressure at a position in the solution domain by identifying core nodes within the solution domain; and the substep of projecting a core pressure onto an outer cavity frozen layer, as it would enable determination of density using PVT data and determination of completion of packing phase.

16. Claim 62 is rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Kataoka et al. (KA)** (U.S. Patent 6,077,472), **Anderson et al. (AN)** (U.S. Patent 4,676,664), **Chen et al. (CH)** (U.S. Patent 6,089,744), and **Talwer et al. (TA)** ("Three dimensional simulation of polymer injection molding: verification", July 1998).

16.1 As per Claim 62, **YU, KE, KA** and **AN** teach molded plastic component formed from a process developed using the method of at least one of claims 1 and 6, as described in Paragraph 6.1 and 6.2 above. **YU, KE, AN** and **CH** teach molded plastic component formed from a process developed using the method of claim 47 as described in Paragraph 12.1 above. **YU, KE** and **TA** teach molded plastic component formed from a process developed using the method of claim 55 as described in Paragraph 14.1 above. **YU** and **KE** teach molded plastic component formed from a process developed using the method of claim 56 as described in Paragraph 15.1 above.

17. Claim 63 is rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al. (YU)** (U.S. Patent 6,096,088) in view of **Kennedy (KE)** ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Sagawa et al. (SAG)** (U.S. Patent 5,408,638).

17.1 As per Claim 63, **YU** and **KE** teach the method of Claim 56. **YU** does not expressly teach that step (d) further comprises the substep of describing linear variation of a process variable throughout each of a plurality of elements. **SAG** teaches that step (d) further comprises the substep of describing linear variation of a process variable throughout each of a plurality of elements (CL7, L3-19), as that provides plurality of models having good speed while trading-off between speed and precision (CL7, L3-16). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **SAG** that included step (d) further comprising the substep of describing linear variation of a process variable throughout each of a plurality of elements, as that would provide plurality of models having good speed while trading-off between speed and precision.

18. Claim 64 is rejected under 35 U.S.C. 103(a) as being unpatentable over **Yu et al.** (**YU**) (U.S. Patent 6,096,088) in view of **Kennedy** (**KE**) ("Flow Analysis of Injection Molds", Hanser Publishers, 1995), and further in view of **Sandstorm (SA)** (U.S. Patent 6,180,201).

18.1 As per Claim 64, **YU** and **KE** teach the method of Claim 56. **YU** does not expressly teach that step (d) further comprises the substep of using a one dimensional analytic function to describe variation of a process variable about a point. **SA** teaches that step (d) further comprises the substep of using a one dimensional analytic function to describe variation of a process variable about a point (CL12, L15-28), as one dimensional conduction dominates in the semisolid in the injection molding and can be determined

using the distance in the thickness direction and the coefficient of thermal diffusivity (CL12, L16-24). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **YU** with the method of **SA** that included step (d) further comprising the substep of using a one dimensional analytic function to describe variation of a process variable about a point, as one dimensional conduction would dominate in the semisolid in the injection molding and could be determined using the distance in the thickness direction and the coefficient of thermal diffusivity.

Allowable Subject Matter

19. Claims 50-52 and 60 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Arguments

20. As per the applicant's arguments, the applicant's attention is requested to the corresponding claim rejections. In addition, the following explanation is provided to further explain the examiner's position.

20.1 As per the applicant's argument that "neither **YU** nor **KE** teach or suggest the use of both a first and a second description of the distribution of a process variable in a fluid injection model", the examiner has used new references **KA** and **AN**.

20.2 As per the applicant's argument that "neither **HA** nor **TA** teach or suggest the use of both a first and a second description of the distribution of a process variable in a fluid injection model", the examiner has used new references **KA** and **AN**.

Conclusion

ACTION IS FINAL

21. Applicant's amendments necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the

advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

22. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dr. Kandasamy Thangavelu whose telephone number is 703-305-0043. The examiner can normally be reached on Monday through Friday from 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kevin Teska, can be reached on (703) 305-9704. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-305-9600.

K. Thangavelu
Art Unit 2123
March 16, 2004

KEVIN J. TESKA
SUPERVISORY
PATENT EXAMINER